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# The Integrated Impact of Manufacturing Sectors on Environment

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**Abstract**

This paper attempts to apply an input-output approach to evaluate the impact caused by the production of a good on the environment, and it involves the retrospective accumulation of effects on the environment produced by energy and materials required directly and indirectly in the production of manufacturing sectors. The accumulation of these effects involves firstly, measuring the impact of energy consumption on the environment (e.g. CO2 emission), secondly, measuring the impact on the environment from energy consumption occurs during the production of the various energies and materials required in the production process



*Keywords:*Manufacturing industries; CO2 emission; energy consumption;

## 1.1 Introduction

This paper attempts to apply an input-output approach to evaluate the impact caused by the production of a good on the environment, and it involves the retrospective accumulation of effects on the environment produced by energy and materials required directly and indirectly in the production of manufacturing sectors. The accumulation of these effects involves firstly, measuring the impact of energy consumption on the environment (e.g. CO2 emission), secondly, measuring the impact on the environment from energy consumption occurs during the production of the various energies and materials required in the production process, and so on.

In the paper, we only consider CO2 as the negative impact on the environment, but similar calculations could also be extend to NOx and SOx. Further, due to the limitation in data, we merely consider products in domestically manufacturing sector. But this method of analysis might be extended to other industries and linkage effect abroad. Thus, along this line of approach, we can consider it as a useful prototype.


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### 1.2 Input-Output Analysis

Input- output approach is often used for assessing the impact of a change in the final demand i sector on all sectors of the economy. The technique used for this purpose is attributed Leontief and is known as the Leontief model. The basic idea of the model is that the amount of sector i's output required for the production of sectorj's output X is 1 be assumed to proportional to sectorj's output Xj. Therefore, if aij is such an input-output coefficient, then:

$$X_{ij} = a_{ij} X_j,\ i,j=1..\ n. \quad (1)$$

The equilibrium between total supply and total demand for each sector is written:

$$X_i = \sum_{j-1}^{n} x_{ij} + F_i,\quad i = 1\ldots n, \quad (2)$$

where $x_{ij}$, is intermediate and $F_i$ final demand.

Substituting equation (1) into equation (2) yields:

$$X_i = \sum_{j-1}^{n} a_{ij} x_j + F_i,\quad i=1\ldots n \quad (3).$$

This relationship between final demand and production also holds in changes:

$$\Delta X_i = \sum_{j-1}^{n} a_{ij} \Delta x_j + \Delta F_i,\ i=1\ldots n, \quad (4)$$

where AF1 and AX1 represent changes in final demand and output of sector i, respectively. Since (3) and (4) are formally identical, we pursue the discussion using the symbols F and X for level or change indifferently.

Note that if the final demand in a given sector i increases by, say, F1, initially production increases by the same amount, X = F;. However, this increase in production raises the intermediate demand for all sectors, including i itself, by X = a1X. To produce these intermediate inputs, however, more intermediate inputs are needed, and there is a third round of effects

xJ = a11X12 . This obviously leads to more and more rounds of effects. Thus, sectoral outputs keep rising as a result of the higher intermediate-goods demand each round of effects generates. But, in each round output increases become smaller and smaller such that their total always has a limit. To calculate this limit, it is easier to write equation (3) in matrix form (where reads "which gives"),

$$X = AX + F \Rightarrow (I - A)X = F \Rightarrow X = (I - A)^{-1} F\ . \quad (5)$$

In this equation, Xis the vector of outputs, X1, i = 1 n; F is the vector of final demands, F1, = 1 n; A is the matrix of $a_{ij}$ 's, i, j = 1,..., n; and I is the unit matrix, which has ones on its diagonal and zeros everywhere else. (I - A)' is a multiplier which can be used to calculate overall changes in sectoral outputs which result from changes in final demand.

Further, we let the impact on the environment generated by the production of per unit of the *jth* good as ej. For convenience in calculation, it is writ following diagonal matrix form,

$$e = \begin{pmatrix} e_1 & & 0 \\ & \ddots & \\ 0 & & e_n \end{pmatrix} \quad \textbf{:}\ \text{Environmental impact diagonal matrix} \quad (6)$$

Let $\mathbf{F} = \begin{pmatrix} f_1 \\ \vdots \\ f_n \end{pmatrix}$ **be** the demand on various goods for the production of manufacturing sectors.

Here, the direct impacts on the environment arises from the production of vector f of goods and services inputs is e·f.

where x is called the total production inducement vector. The total impact on the environment is thus written as

$$e \cdot \Delta X = e \cdot f + e \cdot Af + e \cdot A^2 f + \cdots = e \cdot (I - A)^{-1} \Delta f \tag{7}$$

### 1.3 Evaluation of the Total Effect

It is found that in terms of the total cumulative effect, 4.2 tons(10.008%) of CO2 in the production of per unit of manufacturing sectors. The characteristics of th mulative effect could be summarized as follows. Firstly, Coal sector has the highest level, 888kg of CO2 emission, follow by Natural Gas (421kg), **Electric Power** (183kg), and oil sector (148kg). Secondly, as the direct effect contributed by manufacturing sectors amount to only 105kg, the indirect effect it generated is much larger. Thirdly, the simulation indicates a negative effect of the rise of energy price, which bring out the economy-wide decrease in real GDP is equal to -0.9%. In case that the energy price increases significantly, there is a depression in demand of each industry for energy, and the drop in demand has an obviously adverse effects on the real consumption and investment. The decrease in real consumption and investment is much larger than the drop of real GDP, which implies that the rising energy price contributes to bear out a more efficient usage for energy.

With regards to efficiency in production processes which consume a large amount of energy and produce CO2 emission. It should be noted that China needs to take the trade off between the environment, Economic growth and trade liberalization more seriously. To prevent pollution from reaching a critical threshold (see Tisdell, 2010) China needs to tighten up its environmental regulations, to upgrade manufacturing industry and adopt a more cost-effective pollution abatement strategy.

Table 1: energy consumption and CO2 Emission from per unit production of manufacturing sectors

| | Rate of change of Energy demand relatived to the base period（%） | | |
|---|---|---|---|
| | The energy price is constant | The energy price is Increase by 5% | The energy price is Increase by 10% |
| Coal | 6.034 | 6.322 | 6.609 |
| Intermediate demand | 6.018 | 6.241 | 6.538 |
| Final demand | 8.442 | 9.091 | 9.524 |
| Oil | 0.254 | -0.915 | -2.083 |
| Intermediate demand | 0.257 | -0.924 | -2.104 |
| Final demand | 2.094 | 1.047 | -0.524 |
| Natural Gas | 1.587 | 0.768 | -0.051 |
| Intermediate demand | 1.522 | 0.652 | -0.109 |
| Final demand | 3.100 | 2.569 | 1.683 |
| **Electric Power** | 0.363 | -0.824 | -2.012 |
| Intermediate demand | 0.236 | -0.955 | -2.156 |
| Final demand | 2.206 | 1.160 | 0.099 |
| CO2 | 10.008 | 8.001 | 7.018 |

Source: Calculated from Input-Output Table of China(2007), *China Statistical Yearbook* (2007-11), *China environmnet Statistical Yearbook* (2007-11)), and *China Commerce Yearbook* (2007-11) data.

### 1.4 Conclusion and Suggestions

To China, manufacturing industry has made a significant positive contribution to Chinese economy. China's experience also suggests that China needs to take the trade off between the environment, Economic growth and trade liberalization more seriously. To prevent pollution from reaching a critical threshold (see Tisdell, 2010) China needs to tighten up its environmental regulations, to upgrade manufacturing industry and adopt a more cost-effective pollution abatement strategy. It enabled China to gain access and adopt the best international practice in pollution abatement technology leading to a significant drop in the pollution intensity of its manufacturing industry. It also enabled China to specialize according to its comparative advantage and relocate its resources away from capital, land, and energy intensive dirty industries to technology intensive cleaner industries.

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